

CLAIMS

1. A method of working planning in allocating a plurality of working positions scattered on a workpiece to a plurality of working areas to be simultaneously worked,

5 said method comprising the steps of:

determining an optimal working path for working positions in each working area; and

subsequently determining order of working at the working positions in each working area so that the total
10 working time is minimized in the working areas to be simultaneously worked.

2. A method of working planning in determining order of working at a plurality of working areas scattered on a workpiece, said method comprising the step of:

15 shifting an start point of a working path in each of the plurality of simultaneous working areas so that time for scanning or moving simultaneously performed can be equal, thereby shortening a total working time.

3. A working planning method in determining order of
20 working by applying a traveling salesman problem to a plurality of working positions scattered on a workpiece or working areas set in a workpiece, said method comprising the steps of:

solving the traveling salesman problem, thereby
25 minimizing a length of a tour; and

subsequently detecting a longest movement, and determining start and end points so that the longest movement is removed.

4. A working planning method in determining order of
5 working by applying a traveling salesman problem to a plurality of working positions scattered on a workpiece or working areas set in a workpiece, said method comprising the steps of:

10 solving a traveling salesman problem to minimize a value produced by removing a longest movement from a tour, thereby obtaining a new tour, and

eventually removing the longest movement, and determining start and end points.

5. A working planning method in determining placement
15 of working areas to be worked by working means based on working positions scattered on a workpiece, said method comprising the steps of:

20 provisionally setting a next working area so as to enclose an end point in a first direction not yet enclosed by the working area;

moving said provisionally set working area in a second direction different from said first direction to enclose an end point in the second direction;

again moving said moved working area in the first
25 direction so as to enclose the end point in said first

direction in positions after the movement; and

again moving the re-moved working area in the second direction so as to enclose the end point in said second direction in positions after the re-movement, wherein

5 said steps of moving are repeated to define the next working area.

6. The working planning method according to claim 5, wherein said working area has a square frame orthogonal to said first and second directions.

10 7. The working planning method according to claim 5 or 6, wherein said first and second directions are set to correspond to the moving direction of a workpiece.

8. A method of working planning in determining placement of working areas to be worked by working means
15 based on working positions scattered on a workpiece, said method comprising the steps of:

simply dividing an entire surface of the workpiece into the working areas; and

subsequently removing all the working areas without
20 any working position.

9. A working planning method in determining placement of working areas to be worked by working means based on working positions scattered on a workpiece, said method comprising the step of:

25 repeating the step of placing a working area in a

position with a largest number of working positions not yet enclosed until all the working positions are enclosed.

10. A working planning method, in determining placement of working areas to be worked by working means
5 based on working positions scattered on a workpiece, said method comprising the steps of:

provisionally determining area placement; and

subsequently shifting a working area to a neighborhood and removing an unnecessary working area.

10 11. The working planning method according to claim 10, wherein said area placement is provisionally determined by the method according to claim 5.

12. The working planning method according to claim 10, wherein said area placement is provisionally determined by
15 the method according to claim 8.

13. The working planning method according to claim 10, wherein said area placement is provisionally determined by the method according to claim 9.

14. The working planning method according to claim 10,
20 wherein said working area is shifted to a neighborhood and an unnecessary neighboring area is removed, provided that a point independently belonging to said working area stays within the area.

15. The working planning method according to claim 10,
25 wherein among said working areas, at least two areas joined

at an overlapping location are each shifted to a neighborhood and an unnecessary neighboring area is removed, provided that a point independently belonging to said at least two areas stays within said working areas.

5 16. A working planning method in determining placement of working areas to be worked by working means based on working positions scattered on a workpiece, said method comprising,

10 when the same working position belongs to a plurality of areas, determining said areas to be worked so that number of working positions belonging to each of a plurality of simultaneous working areas is equal.

17. The working planning method according to claim 16, wherein

15 some of the working positions belonging to said plurality of areas are allocated to an area having a greater difference among a plurality of simultaneous working areas,

20 some of the remaining working positions are allocated to a area having a smaller difference, and

eventually remaining working positions are distributed equally among both areas.

18. A working planning method in determining placement of working areas to be worked by working means
25 based on working positions scattered on a workpiece, said

method comprising the step of:

adjusting an area position so that working positions are gathered to center of each working areas.

19. The working planning method according to claim 18,
5 wherein area position is adjusted so that center of an extent of said working positions matches center of the working area.

20. The working planning method according to claim 18,
10 wherein area position is set as near as center of gravity of the working positions, provided that the working positions are within the working area.

21. A working planning method in working a workpiece placed on a stage, said stage being movable in a plurality of directions, said method comprising the step of:

15 determining a moving path for said stage by solving a traveling salesman problem with fixed edge points in which a position to load the workpiece to the stage from a loader is set as a start point of the moving path for said stage, a position before moving the workpiece to an unloader is
20 set as an end point.

22. A working planning method in simultaneously working a workpiece placed on a movable stage by a plurality of working units capable of scanning or moving working means within a working area, said method comprising
25 the step of:

determining an interval between the working units so that number of scanning or moving the working means or number of moving the stage is minimized.

23. The working planning method according to claim 22, wherein the number of scanning or moving said working means and the number of moving the stage are weighted depending on difference in scanning or moving time.

24. The working planning method according to claim 22 or 25, further comprising the steps of:

10 setting the interval of said working units;
 overlapping scanning or moving ranges of the working units at that time, thereby obtaining area placement to minimize number of working areas; and
 calculating the number of scanning or moving of the
15 working means and the number of moving the stage at the time.

25. A working planning method, comprising the steps of:

 performing the process according to claim 22 in a
20 different workpiece direction; and
 automatically employing the workpiece direction which minimizes the number of scanning or moving the working means or the number of moving the stage.

26. A working planning method in working a workpiece
25 using working means capable of scanning or moving in a

plurality of directions, wherein point position data representing working positions or working areas scattered on the workpiece is expressed in a tree type data structure.

27. The working planning method according to claim 26,
5 wherein said tree is a k-dimensional binary search tree.

28. The working planning method according to claim 26 or 27, wherein said tree is used to list point data in each working area after the position of working areas scattered on the workpiece is determined.

10 29. The working planning method according to claim 26, wherein from a root node of said tree, for internal nodes, whether or not to search a child node of a node is judged based on the degree of overlapping between a region corresponding to the child node of the node and a search
15 region, and only when a leaf node is reached, the point data is directly accessed.

30. The working planning method according to claim 26 or 27, wherein process of searching nearest neighbor point to a point of interest is conducted using said tree.

20 31. The working planning method according to claim 30, wherein said process of searching the nearest neighbor point is started from a root node of said tree.

32. The working planning method according to claim 31, wherein a node is searched when a circle centered on the
25 point of interest and having a radius as long as distance

to present nearest neighbor point overlaps a region corresponding to the node.

33. The working planning method according to claim 32, wherein

5 if said node is a leaf node, distances to all the points corresponding to the node in the region are obtained, and it is judged whether each distance is short.

34. The working planning method according to claim 30, wherein

10 each point data piece has information related to a leaf node to which said data piece belongs,

 said process of searching the nearest neighbor point is performed by directly accessing the leaf node having the point of interest whose nearest neighborhood is searched,
15 and then the search is performed in a direction toward the root node of said tree, only if there is a node to be searched.

35. The working planning method according to claim 34, wherein

20 if a circle centered on the point of interest and having a radius as long as distance to present nearest neighbor point and a region corresponding to a node are outside a region corresponding to the present node, a brother node thereof or a brother node of a parent node
25 thereof is searched depending on a degree of how much

outside they are.

36. The working planning method according to claim 30,
wherein said process of searching said nearest neighbor
point and process of searching next nearest neighbor point,
5 using a tree removed of a found nearest neighbor point are
repeated, so that neighbor points are listed in order of
their nearness to the point of interest.

37. The method of working planning according to claim
30, wherein process of searching the nearest neighbor point
10 not yet connected to a working path by said process of
searching the nearest neighbor point and connecting a new
found point of interest to the working path, and process of
searching next nearest neighbor point using the tree
removed of the found point of interest and connecting a
15 next new found point of interest to the working path are
repeated from a start point to an end point to produce the
working path.

38. The working planning method according to claim 36
or 37, wherein the process of removing a found point from
20 said tree is performed by reducing ending number of an
index attached to each point data or by increasing starting
number.

39. The working planning method according to claim 38,
wherein
25 if a found point is removed from said tree, and all

point data in a node disappears, the node is attached with information indicating that it is not necessary to visit the node.

40. A working planning method, wherein a working path
5 determined by a working planning method according to any one of claims 37 to 39 is set as an initial solution in determining order of working by applying a traveling salesman problem.

41. A working planning method, wherein
10 an unnecessary, high load operation is removed by finding a set of areas in which placement of point data in one of the working areas and placement of point data in another working area are relatively matched.

42. The working planning method according to claim 41,
15 wherein said process of searching a set of areas having relatively matched point data placements is performed by the steps of:

producing point position data by adding a prescribed coordinate shift to all the points in one area;

20 visiting one node after another corresponding to a region having said point position data from a root node of a tree in the other area; and

checking whether or not there is point position data matched with said point position data only when a leaf node
25 is reached.

43. The working planning method according to claim 26 or 27, wherein

in the process of enclosing point data in the working area with the minimum number of equal size rectangles,

5 every time a provisional working area is produced by calling a loop, said tree is built both for the provisional working area and provisional point position data in each working area.

44. The working planning method according to claim 26 or 27, wherein said tree is built both for the working area and point position data in each working area when the working area is defined.

45. A working method performing working determined by the working planning method according to any one of claims 15 1 to 44.

46. A computer program for implementing the working planning method according to any one of claims 1 to 44.

47. A working planning device for allocating a plurality of working positions scattered on a workpiece to 20 a plurality of working areas to be simultaneously worked, said device comprising:

working path determining means for determining an optimal working path for working positions in each working area; and

25 working order determining means for determining order

of working in the working positions in each working area so that the total working time in the working areas to be simultaneously worked is minimized.

48. A working planning device for planning working in
5 determining order of working in a plurality of working areas scattered on a workpiece, comprising,

working order shift means for shifting a start point of a working path for each of the plurality of simultaneous working areas so that time for scanning or moving performed
10 simultaneously can be equal among the simultaneous working areas, and shortening the total working time.

49. A working planning device for planning working in
determining order of working by applying a traveling salesman problem to a plurality of working positions
15 scattered on a workpiece or working areas set in the workpiece, comprising,

scanning path determining means for detecting a longest movement after minimizing a round path by solving the traveling salesman problem, and determining start and
20 end points so that the longest movement is removed.

50. A working planning device for planning working in
determining order of working by applying a traveling salesman problem to a plurality of working positions scattered on a workpiece or working areas set in the
25 workpiece, comprising,

scanning path determining means for solving a traveling salesman problem improved to minimize a value produced by removing longest movement from a tour, thereby obtaining tour, and eventually removing the longest
5 movement to determine start and end points.

51. A working planning device for planning working in determining placement of working areas to be worked by working means based on working positions scattered on a workpiece, said device comprising,

10 area placement determining means for repeating a process for defining a next working area,

said process including provisionally setting the next working area so as to enclose an end point in a first direction not yet enclosed by the working area; moving the
15 provisionally set working area in a second direction different from the first direction so that the area encloses an end point in the second direction; again moving said moved working area in the first direction so that the area encloses the end point in said first direction, and
20 again moving said re-moved working area in said second direction so that the area encloses the end point in said second direction in a position after the re-movement.

52. A working planning device for planning working in determining placement of working areas to be worked by
25 working means based on working positions scattered on a

workpiece, comprising,

area placement determining means for simply dividing an entire surface of a workpiece into working areas, and removing all the working areas having no working position.

5 53. A working planning device for planning working in determining placement of working areas to be worked by working means based on working positions scattered on a workpiece, comprising,

10 area placement determining means for repeating a process of placing a working area in a position having the largest number of working positions not yet enclosed until all the working positions are enclosed.

15 54. A working planning device for planning working in determining placement of working areas to be worked by working means based on working positions scattered on a workpiece, comprising,

area placement determining means for provisionally determining area placement, shifting a working area to a neighborhood, and removing an unnecessary working area.

20 55. A working planning device for planning working in determining placement of working areas to be worked by working means based on working positions scattered on a workpiece, comprising,

25 belonging area determining means for determining a working area, when same working positions belong to a

plurality of working areas, said means determining the areas so that number of working positions belonging to each of the plurality of simultaneous working areas is equal.

56. A working planning device for working planning in
5 determining placement of working areas to be worked by working means based on working positions scattered on a workpiece, comprising,

area placement adjusting means for adjusting area positions so that working positions are gathered around the
10 center of each working area.

57. A working planning device for planning working in working a workpiece placed on a stage movable in a plurality of directions, comprising,

moving path determining means for determining a
15 moving path for said stage by solving a traveling salesman problem with fixed edge points wherein a position to load a workpiece to the stage from a loader being set as an start point of the moving path for said stage, a position before transferring the workplace to an unloader being set as an
20 end point.

58. A working planning device for planning working in working a workpiece placed on a movable stage simultaneously using a plurality of working units capable of scanning working means in a working area, comprising,
25 unit interval determining means for determining an

interval of the working units so that number of scanning or moving the working means or number of moving the stage is minimized.

59. The working planning device according to claim 58,
5 further comprising,

workpiece direction determining means for performing the processing by said unit interval determining means in a different workpiece direction, and automatically employing a workpiece direction allowing the number of scanning or
10 moving the working means or the number of moving the stage to be minimized.

60. A working planning device for planning working in working a workpiece using working means capable of scanning or moving in a plurality of directions, comprising:

15 means for storing point position data on points representing working positions or working areas scattered on the workpiece, said data being expressed in a tree type data structure; and

means for determining working area positions and/or
20 order of working using the position data expressed in said tree type data structure.

61. A working device comprising the working planning device according to any one of claims 47 to 60.

62. A computer program for implementing the working
25 planning device according to any one of claims 47 to 60.

63. A working data producing method, comprising the steps of:

determining a working plan based on working position data received from a working device side through a communication line; and

returning the plan to said working device side.

64. The working data producing method according to claim 63, wherein

said working plan is determined by the method according to any one of claims 1 to 44.

65. A computer program for implementing the working data producing method according to claim 63 or 64.

66. A working data producing device, comprising: means for receiving working position data from a working device side through a communication line;

planning means for determining a working plan based on the received working position data; and

transmission means for transmitting the determined working plan back to said working device side.

67. The working data producing device according to claim 66, wherein

said working plan is determined by the method according to any one of claims 1 to 44.

68. A computer program for implementing the working data producing device according to claim 66 or 67.

69. A computer readable recording medium recorded with the computer program according to any one of claims 46, 62, 65 and 68.

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